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NATIONAL DAM SAFETY PROGRAM. LOWER NORTH RIVER NUMBER 83 DAM, N--ETC(U)
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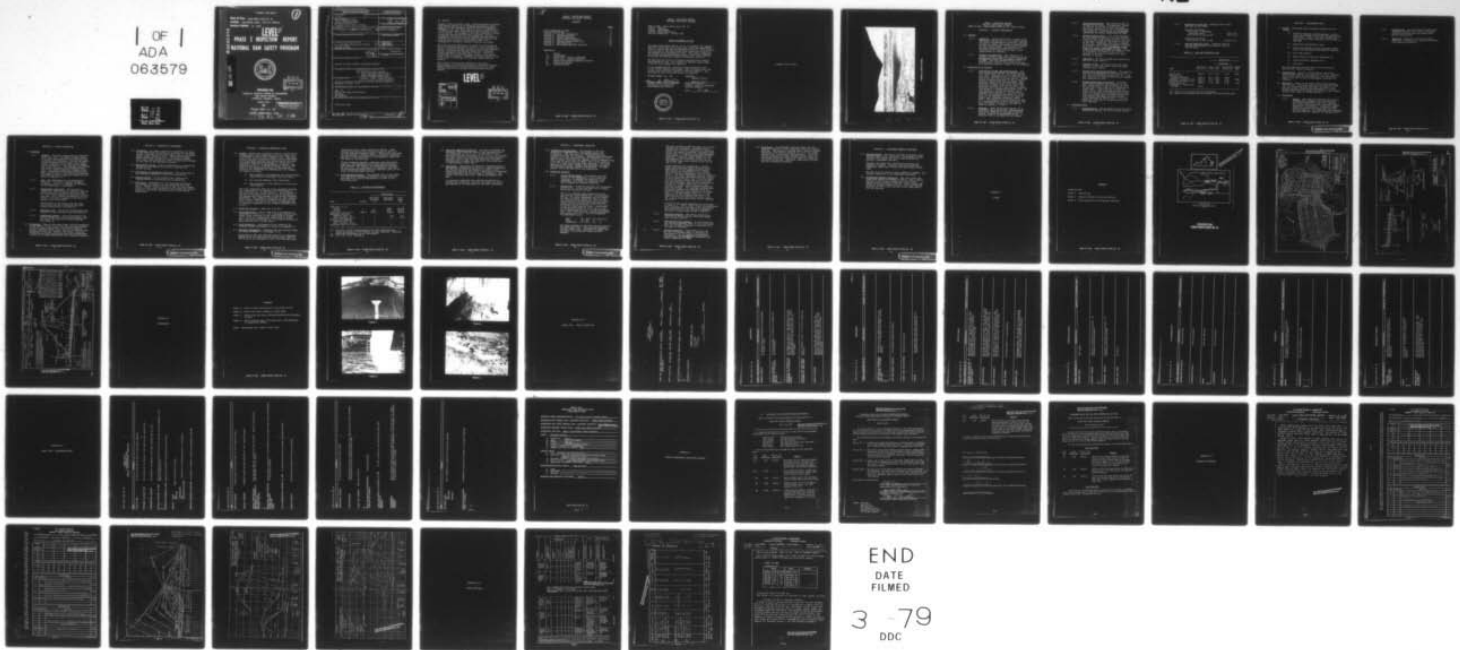
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Name Of Dam: LOWER NORTH RIVER NO. 83

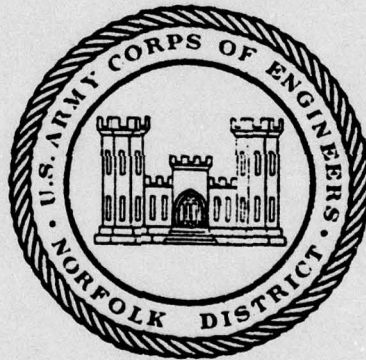
Location: ROCKINGHAM COUNTY, STATE OF VIRGINIA

Inventory Number: VA 16503

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LEVEL II
PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



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PREPARED FOR
NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

AUGUST 1978

BY

✓ **MICHAEL BAKER, JR., INC.**

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20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam and appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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NAME OF DAM: LOWER NORTH RIVER NO. 83

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lower North River No. 83
State: Virginia
County: Rockingham
Stream: Hones Quarry Run
Date of Inspection: 14 June 1978

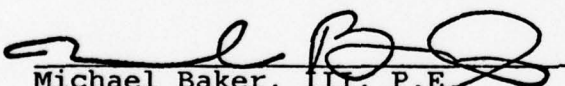
BRIEF ASSESSMENT OF DAM

The Lower North River Dam No. 83 is an earthfill dam approximately 93 feet high and 78 feet long, owned and operated by the U.S. Forest Service and designed by the U.S. Soil Conservation Service on the Lower North River Watershed as part of the Potomac River Watershed Project. The visual inspection and review of engineering data, made in June 1978, indicate no serious deficiencies requiring emergency attention.

The spillway will pass the Probable Maximum Flood without overtopping the dam. No evidence of unstable slope conditions or clear seepage was observed.

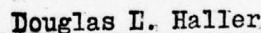
It is recommended that riprap be placed around the end of the outlet conduit and cradle. The low stage trash rack on the riser should be cleaned of trash and debris. The spalling on the outlet pipe should be repaired.

MICHAEL BAKER, JR., INC.


Michael Baker, III, P.E.
Chairman of the Board and
Chief Executive Officer

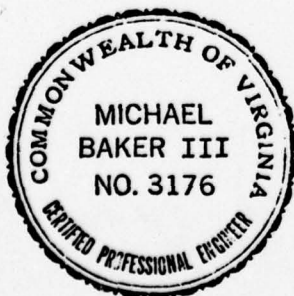
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Original signed by:


Douglas L. Haller

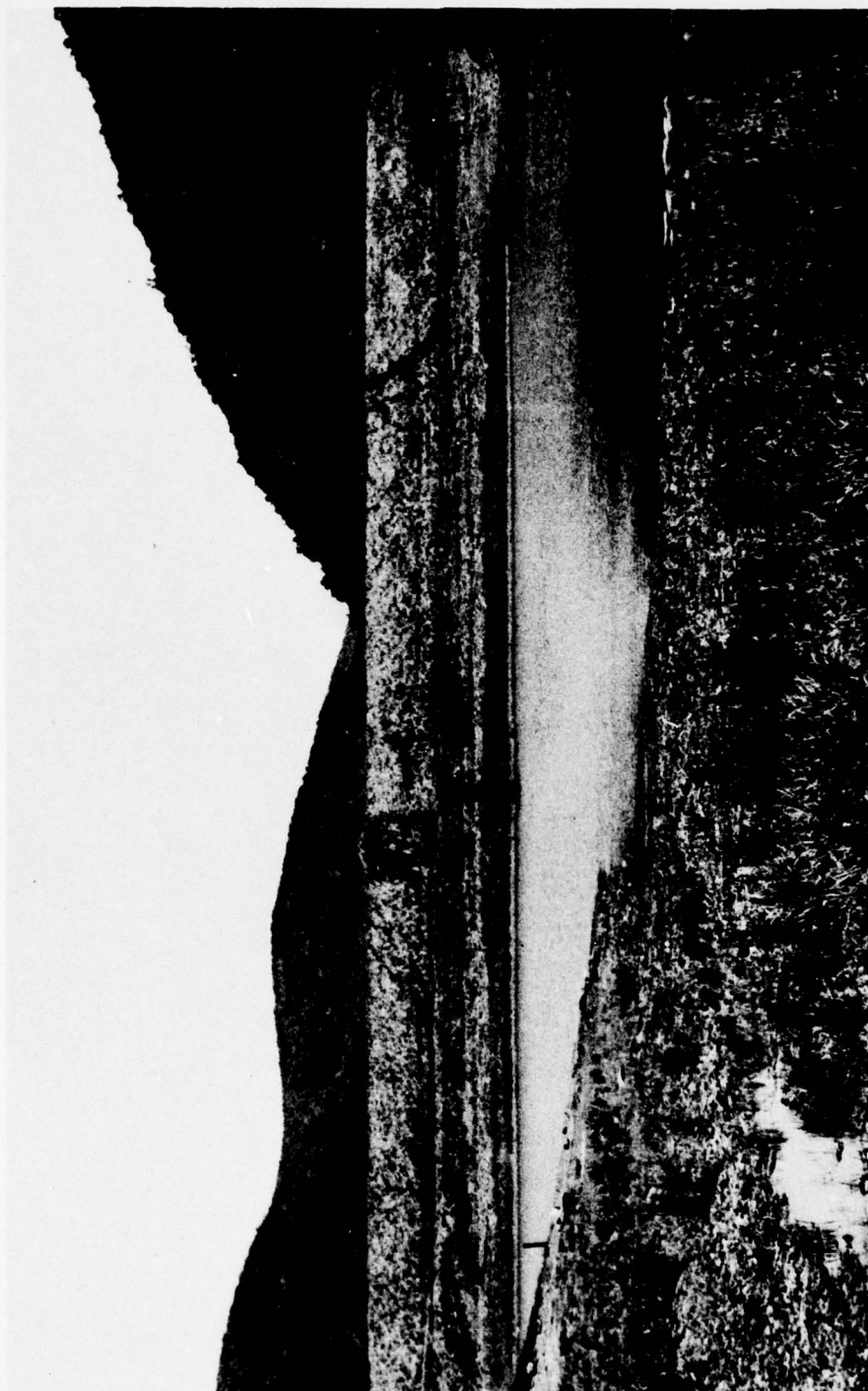
Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

Date: AUG 28 1978



NAME OF DAM: LOWER NORTH RIVER NO. 83

OVERALL VIEW OF DAM



OVERALL VIEW OF DAM

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: LOWER NORTH RIVER NO. 83 ID# VA 16503

SECTION 1 - PROJECT INFORMATION

1.1 General

- 1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.
- 1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams. The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Description of Project

- 1.2.1 Description of Dam and Appurtenances: The Lower North River Dam No. 83 (Hones Quarry) is a zoned earth dam 93.3 feet high and 780 feet long. Seepage control is provided by an impervious core and a cut-off trench. Seepage drains outletting adjacent to the principal spillway conduit have been provided. The emergency spillway is an earth side-channel type with a bottom width of 200 feet. The principal spillway is a drop-inlet structure consisting of a reinforced concrete riser, 36 inch diameter concrete water pipe, and a riprapped stilling basin. The reservoir is used for flood control and there is a side inlet on the upstream face of the riser at normal pool elevation (elevation 1994.0 feet). The reservoir may be drained by use of a hand-operated, 36 inch slide gate. The plan and typical sections of the dam are shown on Plates 1, 2 and 3.
- 1.2.2 Location: Lower North River Dam No. 83 is located on Hones Quarry Run, approximately five miles upstream of the Town of Briery Branch, Virginia in Rockingham County. A Location Plan is included in this report.

NAME OF DAM: LOWER NORTH RIVER NO. 83

- 1.2.3 Size Classification: The maximum height of the dam is 93.3 feet. The reservoir volume to the top of the dam is 1685 acre-feet. Therefore, the dam is in the "intermediate" size category as defined by the Recommended Guidelines for Safety Inspections of Dams.
- 1.2.4 Hazard Classification: Due to the distance of five miles to the Town of Briery Branch, Virginia with a population of about 150, many lives could be lost in the event of failure of the dam. Therefore, this dam is considered in the "high" hazard category as defined by Section 2.1.2 of the Recommended Guidelines for Safety Inspection of Dams. The hazard classification used to categorize dams is a function of location only and has nothing to do with its stability or probability of failure.
- 1.2.5 Ownership: The dam is owned and operated by the U.S. Forest Service.
- 1.2.6 Purpose of Dam: The dam is used for flood control in the Lower North River Watershed (Potomac River Basin).
- 1.2.7 Design and Construction History: The existing facility was designed for the owner by the U.S. Soil Conservation Service (S.C.S.). The dam, built by the Horton Construction Company, was completed in 1968.
- 1.2.8 Normal Operational Procedures: No formal operating procedures are followed for this dam. Normal pool is controlled by an inlet on the side of the riser at an elevation of 1994.0 feet. Since this dam is used for flood control, the principal spillway (riser crest) is located at an elevation of 2022.0 feet with excess flows diverted through the side-channel emergency spillway having a crest elevation of 2053.9 feet. It is not known how often the 36 inch slide gate has been operated.

1.3 Pertinent Data:

- 1.3.1 Drainage Area: The drainage area of the Lower North River Dam No. 83 is 7.92 square miles.

NAME OF DAM: LOWER NORTH RIVER NO. 83

- 1.3.2 Discharge at Dam Site: Maximum flow at the dam site is not known.

Principal Spillway:

Pool level at emergency
spillway crest 219 c.f.s.
Pool level at top of dam 232 c.f.s.

Emergency Spillway:

Pool level at top of dam 18,218 c.f.s.

- 1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are shown in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Reservoir				
	Elevation feet M.S.L.	Area acres	Acre- feet	Capacity	
				Watershed inches (a)	Length feet
Top of dam	2063.3	47.0	2167	5.13	2693
Maximum pool, design surcharge	2058.9	44.2	1967	4.66	-
Emergency spillway crest	2053.9	40.9	1758	4.16	2006
Principal spillway crest	2022.0	21.2	824	1.95	-
Normal pool (b)	1989.0	7.4	482	1.14	634
Streambed at centerline of dam	1970+	-	-	-	-

(a) Based on 7.92 square miles of watershed.

(b) Top of conservation pool and bottom of flood control pool.

NAME OF DAM: LOWER NORTH RIVER NO. 83

SECTION 2 - ENGINEERING DATA

2.1 Design: The design data reviewed included the following:

- 1) As-built drawings indicating plans, elevations and sections of the dam and appurtenant structures. Logs of the test borings and test pits were also included in the as-built drawings.
- 2) Hydrologic and hydraulic data.
- 3) Soils and Geologic Reports (Geologic Report was not of sufficient reproducible quality).
- 4) Soil test results.
- 5) Slope Stability Analyses (Appendix VI).
- 6) Piping Analysis (Appendix VII).
- 7) Work Plan.

All existing data has been filed with the Norfolk District for future reference.

2.2 Construction: The dam, constructed by the Horton Construction Company, was completed in 1968. Construction records were not available for this inspection report, but are on file in Washington, District of Columbia.

2.3 Operation: There are no formal operating procedures for this dam. The slide gate used to drain the reservoir is not periodically operated, and there is no existing policy regarding the frequency of its use. Annual inspections are conducted through a joint effort of the S.C.S. and U.S. Forest Service.

2.4 Evaluation

2.4.1 Design: The Stability Analyses and as-built drawings were adequate for evaluating the structural stability of the dam. However, the as-built drawings show a greatly reduced impervious core section. Foundation conditions were determined using the Soils and Geologic Reports. The hydrologic and hydraulic data provided was adequate for design review.

NAME OF DAM: LOWER NORTH RIVER NO. 83

- 2.4.2 Construction: No construction records were available; however, the as-built drawings indicate modifications and changes made during construction.
- 2.4.3 Operation: Operation of the slide gate should be included in the annual maintenance and inspection program.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

3.1.1 General: The field inspection was conducted on 14 June 1978. No unusual weather conditions were experienced and the reservoir was at normal pool elevation. The dam and appurtenant structures were found to be in good overall condition at the time of the inspection (see Photo 1). The problems noted during the visual inspection are considered minor and do not require immediate remedial treatment. Noteworthy deficiencies observed are described briefly in the following paragraphs. The complete visual inspection check list is given in Appendix III.

3.1.2 Dam: The embankment was in good physical condition. No cracks, unusual movement, sloughing, erosion, or seepage was observed on the embankment or abutments.

3.1.3 Appurtenant Structures: At the time of inspection, some debris was lodged in the low stage trash rack at normal pool (see Photo 2). This debris should be removed as soon as possible, and thereafter periodically in the future, to prevent clogging of the inlet or damage to the trash rack.

The exterior of the outlet pipe has some severe spalling and cracking of the reinforced concrete pipe (see Photo 3).

3.1.4 Reservoir Area: No serious deficiencies were observed in the reservoir area (see Photo 1).

3.1.5 Downstream Channel: The stilling basin and outlet channel are functioning properly, and the riprap as placed is in good condition (see Photo 4).

3.2 Evaluation: None of the above items, with the exception of the debris in the riser trash rack and the spalling of the 36 inch concrete pipe, is serious enough to warrant immediate repair since they do not threaten the integrity of the dam. However, the repair items are considered good maintenance and should be accomplished as part of an annual maintenance and inspection program.

NAME OF DAM: LOWER NORTH RIVER NO. 83

SECTION 4 - OPERATIONAL PROCEDURES

- 4.1 Procedures: No formal operational procedures are used on the Lower North River Dam No. 83 since it is a flood control structure and does not require the use of water supply intake valves or gates. The reservoir under normal conditions remains at an elevation of normal pool 1994.0 feet and has 59.9 feet of additional storage to the crest of the emergency spillway.
- 4.2 Maintenance of Dam: Annual inspections are carried out through a joint effort of the S.C.S. and the U.S. Forest Service.
- 4.3 Maintenance of Operating Facilities: The slide gate is not routinely operated to check its functioning.
- 4.4 Warning System: At the present time, there is no warning system or evacuation plan in operation.
- 4.5 Evaluation: Maintenance of the operating facilities are considered adequate for the functions that they serve. However, formal records of the lift gate checks similar to the annual maintenance and inspection reports should be instituted, perhaps as part of the annual inspections.

NAME OF DAM: LOWER NORTH RIVER NO. 83

SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

5.1 Design: Normal pool (elevation 1994.0), controlled by a drop-inlet on the reservoir side of the riser, was established at the 50 year sediment level. The elevation of the crest (elevation 2022.0) of the drop-inlet to the principal spillway was established at an elevation which would provide storage of a flood with a recurrence interval of approximately 18 months. The capacity (219 c.f.s. with the reservoir level at the crest of the emergency spillway) of the principal spillway was established by consideration of a number of factors including:

- 1) The capability of evacuating the flood storage space within a reasonable time (± 10 days).
- 2) Not passing damaging flows downstream.
- 3) The capability of the reservoir to store the flood waters.

The crest (elevation 2053.9) of the emergency spillway was established at the maximum elevation needed to store the 100 year, 10 day rainfall. The elevation of the top of dam (elevation 2063.3) was established by the maximum elevation reached in passing the freeboard hydrograph. The freeboard hydrograph is that computed from rainfall comparable to Probable Maximum Precipitation (P.M.P.) as used by the Corps of Engineers and is therefore comparable to the Probable Maximum Flood (P.M.F.)

5.2 Hydrologic Records: None were available.

5.3 Flood Experience: The 17 June 1949 flood peaked at a discharge of 11,100 c.f.s. for a drainage area of 23.4 square miles according to the stream gage at Stokesville, which is located about eight miles from the dam. This peak corresponds to a recurrence interval of approximately once in sixty years.

5.4 Flood Potential: Performance of the reservoir by routing various hydrographs is noted in paragraph 5.1.

5.5 Reservoir Regulation: Pertinent dam and reservoir data are shown in Table 1.1, paragraph 1.3.3.

Regulation of the flow from the reservoir is automatic. Normal flows are controlled by the low stage inlet in the riser at an elevation of 1994.0 and the high stage

NAME OF DAM: LOWER NORTH RIVER NO. 83

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drop-inlet with a crest elevation of 2022.0. Water flowing into these inlets flows through the dam in a 36 inch diameter concrete conduit. Water also flows past the dam through an ungated earth side-channel emergency spillway in the event water in the reservoir rises over the crest of the spillway.

Outlet discharge capacity, reservoir area and storage capacity, and hydrograph and routing determinations were obtained from reports and computations furnished by the S.C.S. The routing of the emergency and free-board hydrographs began with the reservoir level at the crest of the principal spillway.

- 5.6 Overtopping Potential: The probable rise in the reservoir and other pertinent information on the reservoir performance in various hydrographs is shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal	Hydrograph		
		Principal Spillway (a)	Emergency Spillway	Free-board (b)
Peak flow, c.f.s.				
Inflow	-	-	6882	18,976
Outflow	-	219	5790	18,450
Peak elev., ft. M.S.L.	1994.0	2053.9	2058.9	2063.3
Emergency spillway				
Depth of flow, ft.	-	-	5.0	9.4
Avg. velocity, f.p.s.	-	-	9.3	13.9
Non-overflow section				
Depth of flow, ft.	-	-	-	-
Avg. velocity, f.p.s.	-	-	-	-
Tailwater elev., ft. M.S.L.	-	-	-	-

- (a) 100 year, 10 day volume produces the most conservatively large indication of flood control storage required. Detailed discharge hydrograph was not determined.
- (b) P.M.F. by C.O.E. standards.

5.7 Reservoir Emptying Potential: The time to drawdown the reservoir level from the crest of the emergency spillway (discharge of 219 c.f.s.) to the crest of the principal spillway (discharge of 177 c.f.s.) is 2.44 days. The time to draw the reservoir down from the principal spillway crest to the low stage inlet is 2.62 days. Drawdown time to empty the reservoir from normal pool is approximately eight hours.

5.8 Evaluation: Hydrologic and hydraulic determinations of the project as prepared by the S.C.S. appear reasonable. The dam and spillway are designed to pass a flood essentially equal to the P.M.F., which would be developed under standards used by the Corps of Engineers. The project will pass the P.M.F. without overtopping the dam.

It should be indicated that conclusions pertain to present day conditions, and that the effect of future development on the hydrology has not been considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 Foundation and Abutments: The bedrock at the site consists of sandstone with interbedded shales and siltstones. The rock has a 12° dip downstream and slightly into the left abutment. Unconsolidated materials consist of a high terrace on the left abutment up to 48 feet in depth, alluvium with cobbles on the floodplain from four feet to thirty feet in depth, and a talus cover up to 10 feet deep on the steep right abutment. The talus material on the right abutment was described as angular red sandstone cobbles, gravels and boulders. At some places, red silty sand fills the interstices.

6.2 Stability Analysis

6.2.1 Visual Observations: No evidence of instability in the embankment or cut-slopes was observed. No seepage was observed in the embankment, abutments or foundation that would suggest an unstable condition.

6.2.2 Design Data: Stability Analyses were performed by the S.C.S. in 1964 and again by R. Stuart Royer and Associates in 1965.

The S.C.S. checked slope stability by both the Swedish Circle Method and a Sliding Block Method. The zoned embankment section chosen for these analyses showed the shell of the dam adjacent to an impervious core with slope ratios varying from one and three-quarters horizontal to one vertical (1.75:1) to 0.5:1. A cut-off trench was not shown. Side slopes of the dam were shown as 2.5:1 over 3:1 on the upstream side and 2.5:1 on the downstream side. The following shear strength parameters were used by the S.C.S. for the foundation and embankment soils:

core	$\bar{\phi} = 32.5^\circ$,	$\bar{c} = 825$ p.s.f.
shell	$\bar{\phi} = 40^\circ$,	$\bar{c} = 0$
foundation	$\bar{\phi} = 35^\circ$,	$\bar{c} = 0$

The shear strength of the core section material was determined from a consolidated undrained triaxial shear test. The shear strengths for the shell and foundation materials were assumed.

NAME OF DAM: LOWER NORTH RIVER NO. 83

The most critical condition shown was failure through the foundation. Upstream trials showed that a 20 feet wide berm at elevation 1995.0 was needed to provide a minimum safety factor over 1.35 against full rapid drawdown. Core slopes of 1.75:1 were assumed for this analysis. A minimum safety factor of 1.61 was computed for a circular failure on the downstream slope with a drain at the toe of the 1.75:1 core.

Slope stability was checked by R. Stuart Royer and Associates using the Water Units Application to the Swedish Circle Method. This method was developed by W. A. Brown, Division of Water Resources, State of California. The zoned embankment section analyzed by R. Stuart Royer and Associates was similar to that chosen by the S.C.S., with the exception of the core slopes and cut-off trench. For these analyses, the core was indicated as having 0.5:1 slope ratios and a cut-off trench was shown. Shear strength parameters were not changed. All upstream analyses were performed assuming full drawdown from the emergency spillway crest elevation to normal pool. A minimum safety factor of 1.30 was computed for the upstream side after a 16 feet wide berm was added at elevation 2023. The minimum downstream safety factor computed was 2.18.

A check of the piping potential was also made by the S.C.S., and R. Stuart Royer and Associates. Both concluded that because of the gradations and plasticities of the expected embankment materials, piping would not be a problem.

- 6.2.3 Operating Records: The yearly inspections indicate no deteriorating conditions beyond minor surface erosion.
- 6.2.4 Post-Construction Changes: No alterations of the dam were apparent since it was constructed with the possible exception of addition of a few feet of freeboard.
- 6.2.5 Seismic Stability: Lower North River Dam No. 83 is in Seismic Zone 2, and there is considered to be no hazard of earthquakes according to the Recommended Guidelines for Safety Inspection of Dams.

6.2 Evaluation: The embankment section chosen for the Stability Analyses is not compatible with the as-built drawings. The as-built drawings show a greatly reduced impervious core section compared to 0.5:1 core slopes assumed by R. Stuart Royer and Associates. Since the failure surface would pass through stronger material, the change should not reduce the factor of safety for stability of the dam. Therefore, additional analyses are not considered necessary.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

- 7.1 Dam Assessment: The dam is designed to prevent overtopping under P.M.F. conditions. No seepage or slope failures were noted that would indicate potential piping or embankment failure.

The data available were sufficient to evaluate the adequacy of design. The data obtained during the inspection agree very closely with the as-built drawings.

The dam will not require urgent remedial treatment, and further inspection is not considered necessary.

- 7.2 Recommended Remedial Measures: The riser inlet and trash rack should be cleaned of debris, and it should continue to be cleaned frequently in the future. Riprap should be placed around the outlet conduit and cradle to prevent further erosion. The cracking and spalling of the 36 inch concrete outlet pipe should also be repaired.

NAME OF DAM: LOWER NORTH RIVER NO. 83

APPENDIX I

PLATES

CONTENTS

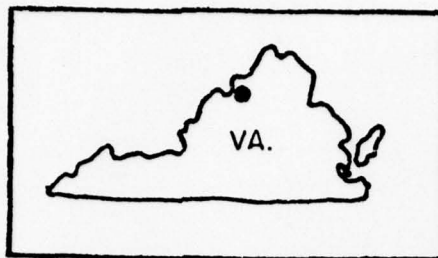
Location Plan

Plate 1: Plan of Dam

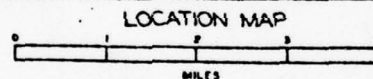
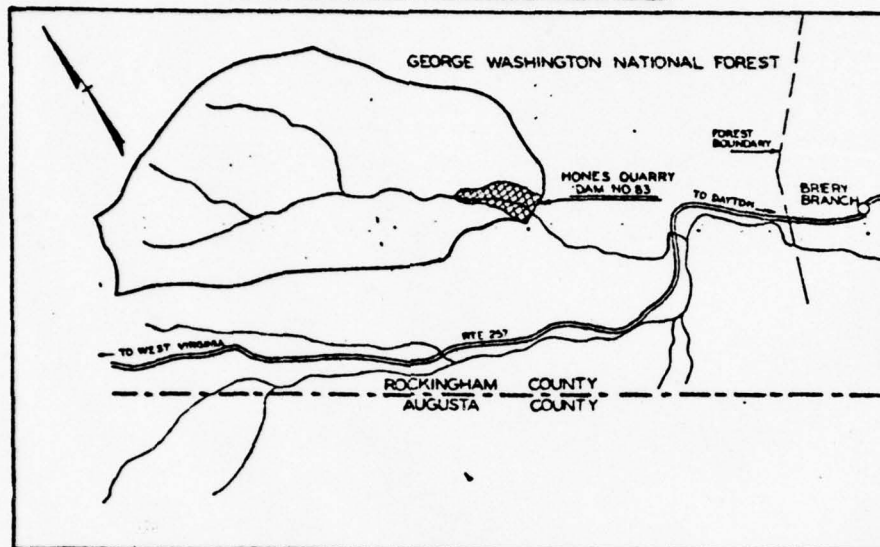
Plate 2: Typical Section of Dam and Profile

Plate 3: Plan and Profile of Principal Spillway

NAME OF DAM: LOWER NORTH RIVER NO. 83

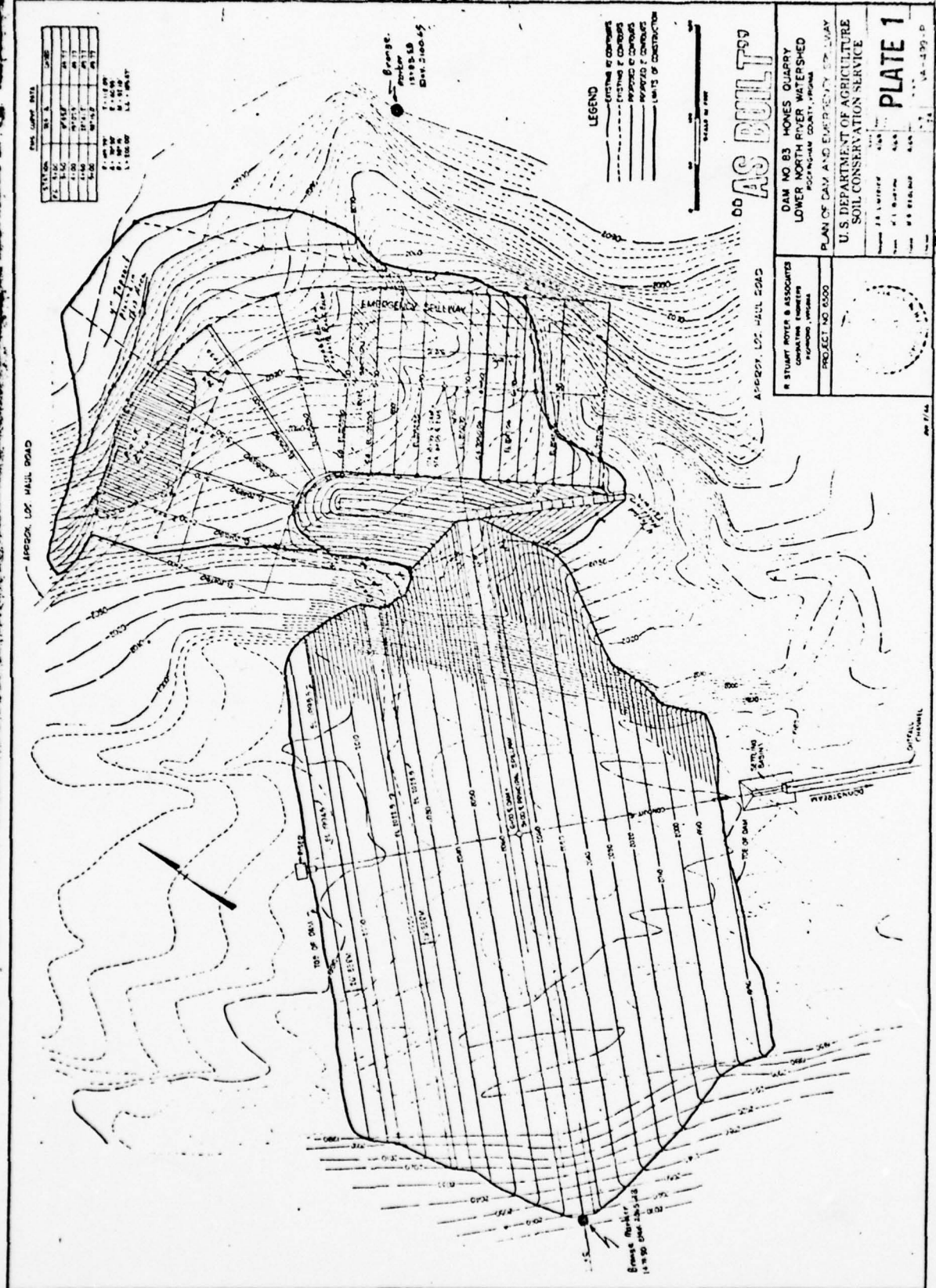


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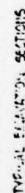
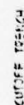
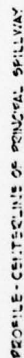
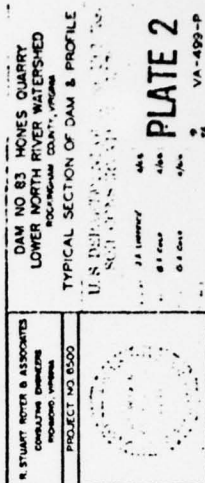


LOCATION PLAN LOWER NORTH RIVER NO. 83

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APPENDIX II

PHOTOGRAPHS

CONTENTS

- Photo 1: View of Riser and Reservoir From Crest of Dam
- Photo 2: Riser with Debris Lodged in Trash Racks
- Photo 3: Outlet Pipe and Cradle Showing Spalling and Cracking of Pipe
- Photo 4: View of Outlet Pipe, Stilling Basin, and Beginning of Downstream Channel.

Note: Photographs were taken 14 June 1978.

NAME OF DAM: LOWER NORTH RIVER NO. 83



PHOTO 1



PHOTO 2



PHOTO 3



PHOTO 4

APPENDIX III

CHECK LIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase 1

Name Dam Lower North River No. 83 County Rockingham State Virginia Coordinates Lat. 3828.2
(Hones Quarry) Long. 7908.6

Date Inspection 14 June 1978 Weather Sunny, Clear Temperature 80°F.

Pool Elevation at Time of Inspection 1994.0' M.S.L. Tailwater at Time of Inspection 1970.2' M.S.L.

III-1

Inspection Personnel:

MICHAEL BAKER, JR., INC.:

M. H. Moore
M. Mill
T. W. Smith

T. W. Smith Recorder

Lower North River No. 83

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No surface cracks were observed on the embankment or abutment slopes.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE III-2	No unusual movement or cracking at or beyond the toe was observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	No sloughing or erosion of the embankment and abutment slopes was observed. High water marks (trash line) were observed on the upstream slope. The embankment appears to have been constructed with 2.5:1 slopes.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Crest alignment is good. No bulging or bowing was observed.	
RIPRAP FAILURES	Riprap around the outlet pipe and cradle has settled or washed away and has left part of the pipe and cradle cantilevered. Additional riprap should be placed around the pipe to prevent further erosion.	

Lower North River No. 83

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM III-3	No erosion or clear seepage was observed at the junction of the embankment and abutment, spillway and dam.	
ANY NOTICEABLE SEEPAGE	No noticeable seepage was observed.	
STAFF GAGE AND RECORDER	These were not present.	
DRAINS	Two seepage drains have been provided and are located on either side of the outlet pipe.	

Lower North River No. 83

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Some severe spalling of the exterior of the outlet pipe has taken place. However, this presents no serious problem at present because it does not affect the efficiency of the pipe.	
INTAKE STRUCTURE HHH-4	Some debris was observed lodged in the low stage trash rack on the concrete riser. Debris should be removed now and be periodically removed in the future. No signs of severe spalling and cracking on the riser.	
OUTLET STRUCTURE	The riprap in and around the stilling basin is functioning properly. No water was observed flowing from the two drains on either side of the outlet pipe.	
OUTLET CHANNEL	The outlet channel is in good condition.	
EMERGENCY GATE	No emergency gates. The only gate is on the upstream side of the riser and is operated from the top of the riser by a hand crank to drain the reservoir.	

Lower North River No. 83

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

CONCRETE WEIR

None exists.

APPROACH CHANNEL

Consists of unimproved road and grasses. No noticeable erosion was observed.

III-5

DISCHARGE CHANNEL

Consists of unimproved road and grasses. No noticeable erosion was observed.

BRIDGE AND PIERS

None exist.

Lower North River No. 83

INSTRUMENTATION

<u>VISUAL EXAMINATION</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
MONUMENTATION/SURVEYS	None were observed.	
OBSERVATION WELLS	None were observed.	
WEIRS	None were observed.	
PIEZOMETERS	None were observed.	
OTHER		

Lower North River No. 83

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SLOPES

The reservoir slopes appeared to be stable.
No sloughing or sliding was observed.

SEDIMENTATION

Only minor sedimentation was noted.

III-7

III-7

Lower North River No. 83

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF		OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--	--------------	----------------------------

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

The condition of the downstream channel was generally good with no major restrictions or obstructions.

SLOPES

The slopes of the downstream channel appeared to be stable. No sloughing or sliding was observed.

HHH-8

APPROXIMATE NO.
OF HOMES AND
POPULATION

Less than one mile downstream of the dam is the Hones Quarry camping and picnicking area. Just over three miles downstream is the Town of Briery Branch with about 30 to 40 homes and a population of 100.

APPENDIX IV

CHECK LIST - ENGINEERING DATA

Lower North River No. 83

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	The plan of this dam is shown on the as-built drawings.
REGIONAL VICINITY MAP	The vicinity map is presented in this report as the Location Plan.
CONSTRUCTION HISTORY	The contractor and completion date were obtained from the C.O.E.
TYPICAL SECTIONS OF DAM	Typical sections are included in the as-built drawings and are presented in this report as Plates 2 and 3.
HYDROLOGIC/HYDRAULIC DATA	Hydrologic and hydraulic calculations were available.
OUTLETS - PLAN and DETAILS	Shown on the as-built drawings.
- CONSTRAINTS and DISCHARGE RATINGS	Contained in the hydrologic/hydraulic calculations.

RAINFALL/RESERVOIR RECORDS No rainfall or reservoir records are available at the dam.

Lower North River No. 83

ITEM	REMARKS
DESIGN REPORTS	A design report was made available for this inspection report.
GEOLOGY REPORTS	A geologic report was made available for this inspection report.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Hydrology and hydraulic calculations were available. Stability analyses were made available for this report.
IV-2 MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Boring records and results of field permeability and water pressure tests are presented in the as-built drawings.
POST-CONSTRUCTION SURVEYS OF DAM	No known post-construction surveys were made available.
BORROW SOURCES	Borrow areas are shown on the as-built drawings.

Lower North River No. 83

ITEM	REMARKS
MONITORING SYSTEMS	No monitoring systems have been provided.
MODIFICATIONS	Data obtained during the inspection agrees very closely with the as-built drawings indicating that no major modifications were made.
HIGH POOL RECORDS	None were available.
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None were available.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	No prior accidents or dam failures have been noted.
MAINTENANCE OPERATION RECORDS	Annual Inspection Reports were provided by the S.C.S. The S.C.S. and U. S. Forest Service conduct annual inspections with recommendations for maintenance and upgrading of the dam and reservoir if needed.

Lower North River No. 83

ITEM	REMARKS
SPILLWAY PLAN and SECTIONS DETAILS	This information is contained in the as-built drawings.
OPERATING EQUIPMENT PLANS & DETAILS	Information on pond drain contained in the as-built drawings.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 7.92 square miles of National Forest
ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1989.0 (482 acre-feet)
ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): East-southwest crest-
2053.9 (1758 acre-feet)
ELEVATION MAXIMUM DESIGN POOL: 2058.9 feet (1967 acre-feet)
ELEVATION TOP DAM: 2066.3 (constructed), 2063.3 (settled)

CREST: Emergency Spillway

- a. Elevation 2053.9
- b. Type Earth side-channel
- c. Width 200 feet
- d. Length 200 feet (approach length)
- e. Location Spillover left abutment
- f. Number and Type of Gates None

OUTLET WORKS:

- a. Type Concrete riser with drop-inlet
- b. Location Riser in reservoir with reinforced concrete pipe
extending to stilling basin
- c. Entrance inverts 2022.0 (principal riser inlet)
- d. Exit inverts 1975.5 feet (invert of 36 inch outlet pipe)
- e. Emergency draindown facilities None

HYDROMETEOROLOGICAL GAGES: None Available

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE Unknown

APPENDIX V

ANNUAL MAINTENANCE INSPECTION REPORTS

S... JOAH VALLEY SOIL AND WATER CONSERVATION DISTRICT
Report of Annual Maintenance Inspection of Watershed Dams in
LOWER NORTH RIVER WATERSHED PROGRAM

April 12, 1978

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An inspection was made on 5 dam sites in Lower North River Watershed.
Those present on the inspection were:

Gerald Fawley	Chairman District Board
James Moyers	Chairman Watershed Committee
Arlis Frymyer	District Director
John Crist	Soil and Water Conservation Commission
Don Parslow	U.S. Forest Service
Randy Maupin	Soil Conservation Service

The following observations were made by members of the inspection party.

<u>Site No.</u>	<u>Date Completed</u>	<u>Date of last Inspection</u>	<u>Remarks</u>
22 B	4-67	4-23-77	Additional rail or large stone needed to control traffic in borrow area above spilway where new guard rails were placed. Work reported needed in Borrow Area C has not been completed.
81 C	10-75	-	Site in good condition. Suggest top of dam be fertilized at regular intervals to maintain grass stands.
80	3-67	4-20-77	Repairs needed on path that has been worn to waters edge on wet side of dam.
83	4-65	4-20-77	Vehicle traffic has worn off vegetation in several areas. No repair needed at this time.
78	11-65	4-20-77	Trash rack needs repair. Bolts broken that hold steel bars in place. Vegetation has been worn off by vehicle traffic in several areas but repairs not suggested at this time.

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SHENANDOAH VALLEY SOIL AND WATER CONSERVATION DISTRICT
REPORT OF ANNUAL MAINTENANCE INSPECTION OF WATERSHED DAMS IN

LOWER NORTH RIVER WATERSHED PROGRAM

May 28, 1976

On May 28, 1976 E. B. Craun, Shenandoah Valley Soil and Water Conservation District Director; Don Parslow, U. S. Forest Service; and Randy Maupin, District Conservationist Soil Conservation Service, made an annual maintenance inspection of the completed flood control structures in Rockingham County, Virginia.

The following observations were made by the members present on the inspection team:

- Dam No. 78 -- Area between highway and lake has a steep bank that is sloughing off of approximately 1,000 square feet. It should be overseeded with a mixture of fescue and sercia lespedeza plus fertilizer.
- Dam No. 83 -- Upper borrow area shows evidence of sheet erosion. Suggest that overseeding be done over the approximate 2 acres with a mixture of fescue and sercia lespedeza. Gully on south side of road at second waterbreak up stream from spillways. Forest service will take care of this problem.
- Dam No. 80 -- On dry side of dam traffic is apparently stopped and it is felt that it will revegetate naturally. Foot path on wet side of dam near center is still getting traffic and will need further study to determine remedy.
- Dam No. 22B -- Borrow area no. C has break in diversion also about $\frac{1}{4}$ acre bare of vegetation. This area needs attention as soon as possible. On dry side of dam jeep trail is still being used. Gate has not been installed, therefore, need to inquire as to status from city of Harrisonburg.

This report is concurred by:

E. B. Craun
E. B. Craun, Shenandoah Valley Soil and Water
Conservation District Director

Randolph J. Maupin
Randolph J. Maupin, District Conservationist, Soil
Conservation Service

Don Parslow
Don Parslow, United States Forest Service

DISTR: State Ofc.
Area Office
Rockingham Ofc.
U.S. Forest Service
Shenandoah Valley SWCD
City of Harrisonburg

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<u>Site No.</u>	<u>Date Completed</u>	<u>Date of last Inspection</u>	<u>Remarks</u>
22 B	4-67	5-28-76	Vehicle traffic on the dry side of Dam has worn away vegetation. Vehicle traffic into borrow area east of the spillway has created two small gullies approximately 200 feet long. Traffic control and seeding needed. Borrow area C above the lake site has a break in berm and some bare areas above and below. 1/3 acres of revegetation needed.

Mr. Locker agreed that the City of Harrisonburg will assist the District with making the necessary repairs on this site.

This report is concurred by:

Carl S. Lively, Shenandoah Valley Soil and Water Conservation District

Gerald E. Fawley, Shenandoah Valley Soil and Water Conservation District

Harold H. Bush, Shenandoah Valley Soil and Water Conservation District

Don Parslow, United States Forest Service

Randolph J. Maupin, District Conservationist, Soil Conservation Service

Edward Loker, City of Harrisonburg

SHENANDOAH VALLEY SOIL AND WATER CONSERVATION DISTRICT
Report of Annual Maintenance Inspection of Watershed Dams in
LOWER NORTH RIVER WATERSHED PROGRAM

April 20 and 23, 1977

On April 20, 1977 Carl Lively and Gerald Fawley, District Directors, and Randy Maupin, District Conservationist, Soil Conservation Service, made an annual maintenance inspection of Dam Sites #78, Briery Branch, #83, Hone Quarry, and #80, Union Springs. Don Parslow of the U.S. Forest Service was called on a forest fire and was unable to make the inspection tour with the group, but had visited site #78 and #80 recently.

The following observations were made by members of the inspection team:

April 20, 1977

<u>Site No.</u>	<u>Date Completed</u>	<u>Date of last Inspection</u>	<u>Remarks</u>
78	11-65	5-28-76	Area sited as needing seeding in last years report in stabilizing. Vehicle traffic is creating damage to outer slope of spillway. Seeding not needed at this time but control of traffic needed. Few large logs on wet slope of Dam should be removed.
83	4-65	5-28-76	Vehicle traffic on steep slopes in borrow area needs control. Few large logs on wet slope of Dam need removal.
80	3-67	5-28-76	Traffic near the center on the wet side of the Dam is continuing. Vegetation is being worn away. This is not a hazard to the structure at this time.

April 23, 1977

Dam #22 B was inspected by Harold H. Bush, District Director, Ed Locker, City of Harrisonburg, Don Parslow, U.S. Forest Service, and Randy Maupin, District Conservationist, Soil Conservation Service.

APPENDIX VI

STABILITY ANALYSES

R. STUART ROYER & ASSOCIATES
CONSULTING ENGINEERS **RICHMOND, VIRGINIA**

BY C.A.W. DATE 7/65 SUBJECT DAM No. 83 - HONES QUARRY SHEET NO. 1 OF 14
CHKD. BY _____ DATE _____ JOB NO. VA-499
REL 2/66 STABILITY ANALYSIS

Slope stability was checked using the Water Units Application to the Swedish Circle Method as developed by W.A. Brown, Division of Water Resources, State of California. This method provides a graphical method which greatly facilitates the solution of trial circles and at the same time gives a clear picture of the relative forces involved.

Using the Water Units Method six trial centers were used on the Upstream Slope and four trial centers were used on the Downstream Slope. All upstream analyses were done assuming full drawdown from the Emergency Spillway Crest Elevation to Normal Pool, which is the most serious condition of soil forces likely to develop. The minimum upstream safety factor computed was 1.14 for a circle through upstream shoulder and tangent to the alluvium line with a radius of 150'. Analysis on sheet 3/14 and on sheet 4/14 having radii of 150' and 110' respectively indicate safety factors below the minimum of 1.30 required by the Soil Conservation Service standards. Therefore the addition of a berm on the upstream slope is indicated to provide additional moment to the forces resisting rotation. Consequently a berm 16 ft wide was added at elevation 2023 (slightly above riser crest elevation) and additional stability analysis performed (Sheets 13/14 and 14/14). These two analyses with radii of 150' and 110' provide safety factors of 1.30 and 1.37 which are acceptable. The minimum downstream safety factor computed was 2.18 for a circle with 200' radius lying entirely in the shell material.

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To be used to report to field offices data used for slope stability analyses and the results of the analyses.
The right side of the form will be used for a sketch of the embankment on which the analyses have been made.

FORM 303-501
10-58

SOIL CONSERVATION SERVICE
SOIL MECHANICS LABORATORY
SUMMARY - SLOPE STABILITY ANALYSIS

Flood Plain Section

State VIRGINIA Project HONE GUARRY CREEK SITE #2

Date 9-25-66 Analysis Made By A.W.L. Checked By CGN

Method of Analysis SWEDISH CIRCLE

Location of Material		THIS PAGE IS BEST QUALITY PRACTICABLE FROM COPY FURNISHED TO DDC							
Sample No.									
γ_d									
γ_m		See Sheet 1 of 2 for Materials list							
γ_s									
γ_b									
Condition	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.
ϕ									
Tan ϕ									
K									
C									

UPSTREAM SLOPE			
Trial	Slope	Conditions	Fs
1	2 1/2:1	Full drawdown - 10' berm @ elev. 1995 - Arc cut from top shldr thru zoned emb (Core slope 1/2:1) & 22' found (35.0°-0)	1.45
1A	2 1/2:1	Same as 1 except core slope 1 1/2:1	1.23
2	2 1/2:1	Full drawdown - 10' berm @ elev. 1995 - Arc from midpoint of top thru zoned emb (1 1/2:1 core slope) & 22' found (35.0°-0)	1.62
3	2 1/2:1	Full drawdown - 10' berm @ elev. 1995 - Arc cut from top shldr thru zoned emb (1 1/2:1 core slope) & 22' found (35.0°-0)	1.38

DOWNSTREAM SLOPE			
Trial	Slope	Conditions	Fs
4	2 1/2:1	Drawn to top of 1 1/2:1 Core - No berm - Arc cut from top shldr thru zoned emb (1 1/2:1 core slope) & 22' found (35.0°-0)	1.92
		* Zoned Emb = Core - (32.5°-92.5°) Shell - (40.0°-0)	
		Sat shear values used on all trials	

SOIL CONSERVATION SERVICE
SOIL MECHANICS LABORATORY
SUMMARY - SLOPE STABILITY ANALYSIS

State VIRGINIA Project HONE QUARRY CP. SITE # 83
Date 10-5-64 Analysis Made By TCH Checked By CCN
Method of Analysis SWED. CIRCLE

Location of Material.											
Sample No.											
γ_d											
γ_m											
γ_s											
γ_b											
Condition	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	
ϕ											
$\tan \phi$											
K											
C											

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UPSTREAM SLOPE			
Trial	Slope	Conditions	Fs
B	2 1/2:1	Full drawdown, 10' berm at el. 1995 - Arc from app. shldr thru zoned *emb (core slope 1 3/4:1) and 22' found. (35°-0)	1.33
9	2 1/2:1	Full drawdown, 10' berm at el. 1995 - Arc from app. shldr thru zoned *emb (core slope 1 3/4:1) and 22' found. (35°-0)	1.50
10	2 1/2:1	Full drawdown, 10' berm at el. 1995 - Arc from same slope thru upstream shell (40°-0) (core slope 1 1/2:1) and 22' found. (35°-0)	1.45
BA	2 1/2:1	Same as #8, but 20' berm at el. 1995.	1.35

DOWNSTREAM SLOPE			
Trial	Slope	Conditions	Fs
11	2 1/2:1	Drain at toe of 1 3/4:1 core slope - No berm - arc from app. shldr thru zoned emb. (1 3/4:1 core slope) and 22' found. (35°-0)	1.61
		* Zoned Emb - Core (32.5'-025) 1/2:1 or 1 3/4:1 shell (40°-0)	
Sliding 31-1		Same as above -	1.75

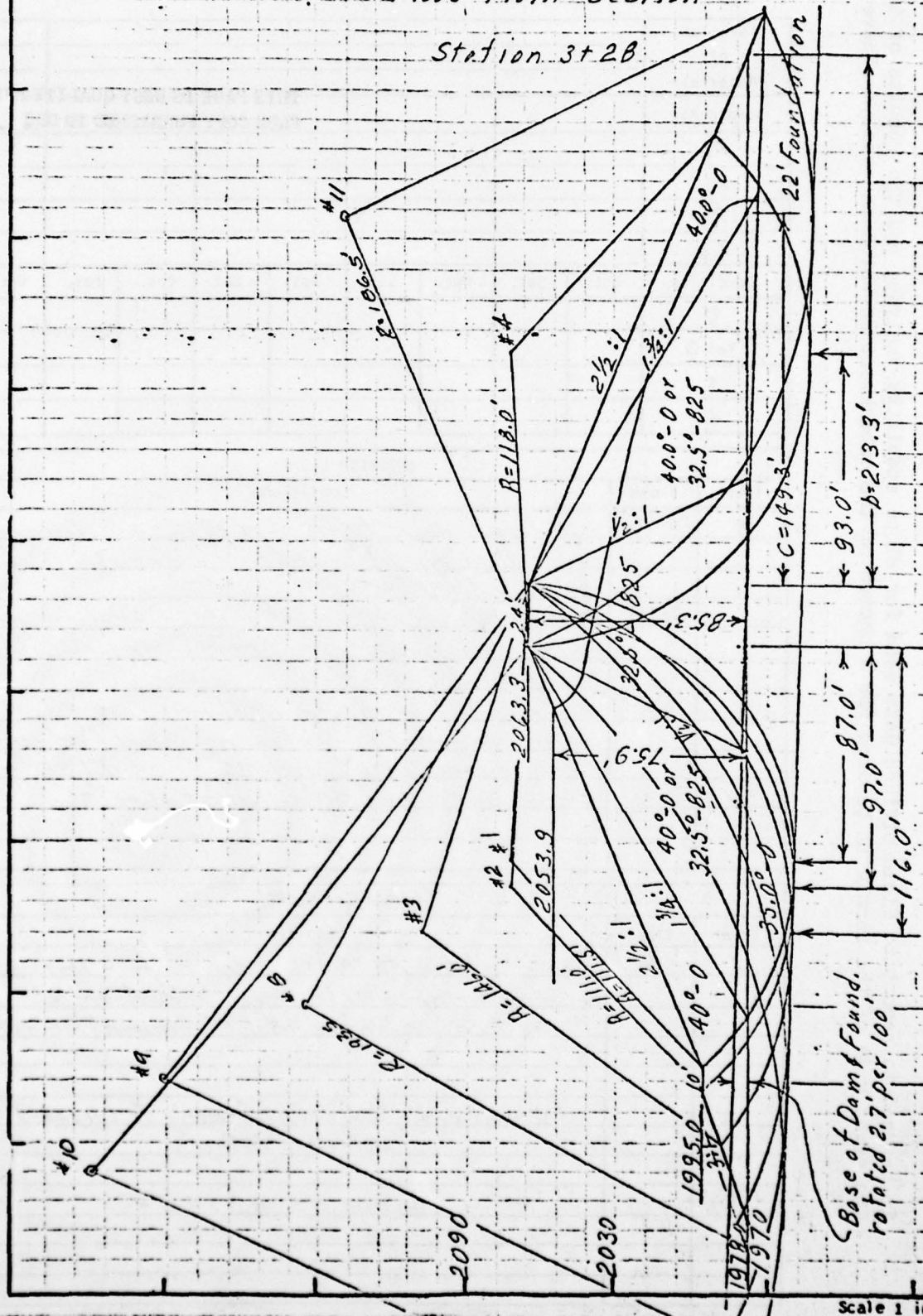
To be used to report to field offices data used for slope stability analyses and the results of the analyses. The right side of the form will be used for a sketch of the embankment on which the analyses have been made.

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Continuation of Sheet 3044
Hone Quarry Creek Site #E2
Virginia

Flood Plain Section

Station 3+28



VI-4

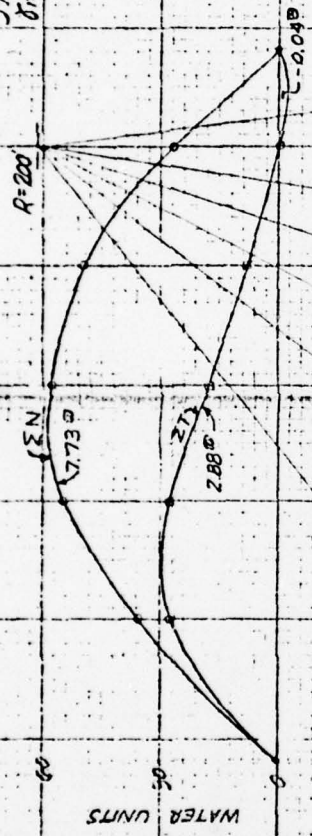
Scale 1 inch = 50 Feet

6-15-66

HONE QUARRY CREEK SITE-83 Stability Analysis - Downstream Slope 8m Condition (End Construction)

6/30/65
LAW
REV. 2/21/66

$\gamma = 30' H/V$



FORCES

1. $N \tan \phi = 900 \times 0.24 = 216$ (7.73)

$= 56,160 [6.48]$

$N \tan \phi = 364,500$

2. $T = 900 \times 0.24 (2.88 - 0.04)$

$= 56,160 (2.84)$

$T = 159,400$

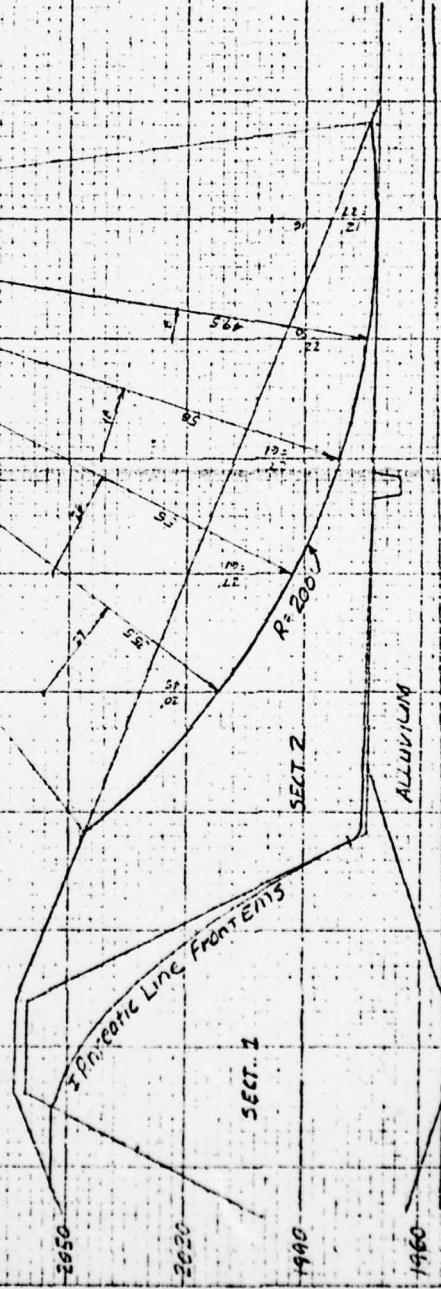
3. $SF = N \tan \phi$

$= 364,500$

$159,400$

$SF = 2.18$

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SECT	WATER UNITS	ϕ	$\tan \phi$	$\bar{\phi}$	$\bar{\gamma}$
1	216	52.5	.637	825	134.5
2	226	40	.839	0	141
ALLUVIUM ROCK	221	35	.700	0	138
					141

HONE QUARRY CREEK - SITE 83

Stability Analysis - Upstream Slope - with Full drawdown from EMS to Normal Pool

$\theta = 30' HqV$

FORCES

$$1. NTAN\phi = 900 \times 624 [-839 (6.31 \times .07 = .44)]$$

$$= 56160 [-839 (6.35)]$$

$$= 56160 [5.37]$$

$$NTAN\phi = 302,000 \#$$

$$2. T = 900 \times 624 (4.01 = 0.46)$$

$$T = 56160 (4.15)$$

$$T = 233,000 \#$$

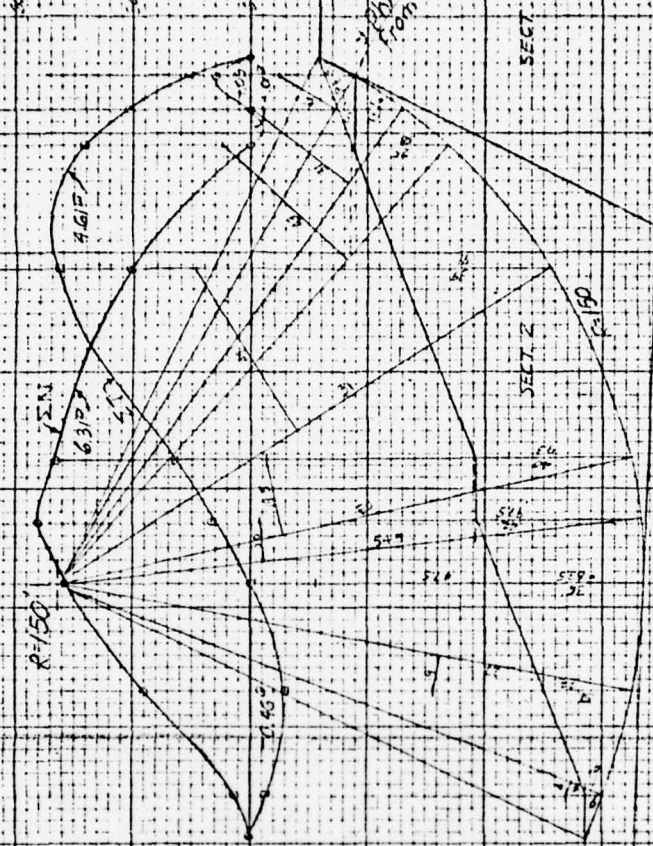
$$3. SF = \frac{NTAN\phi}{T}$$

$$= \frac{302,000 \#}{233,000 \#}$$

$$SF = 1.30 = 1.30 \text{ allowable}$$

OK

WATER UNITS



APPENDIX VII

PIPING ANALYSIS

TABLE 1 - CLASSIFICATION OF EMBANKMENT

Group number	Soil type	AASHTO's airfield classification system symbols	Approximate Ranges of Soil Properties				Number of dams in each soil group	Degree of resistance (1) greatest to (6) least	Piping ^a	Cracking ^b		Relative Importance of Moisture-Density Control	
			Median grain-size D ₅₀ (mm)	Plasticity index ^c	Liquid limit	Per-cent clay sizes (0.005 mm)				Degree of susceptibility (1) greatest to (6) least	Susceptibility to cracking when compacted dry	Degree of importance of control (1) greatest to (6) least	Consequence of inadequate moisture control
I	Sands and gravels with plastic fines	SC SF GC GF	0.15-5.0	8-15	20-50	5-30	6	(3)	Intermediate resistance. Heavier compaction and higher plasticity index increase resistance.	(3)	Intermediate susceptibility may crack only under extreme combinations of conditions.	(5)	May fail by cracking or piping only under severe combination of detrimental conditions.
II	Sands and gravels with non-plastic fines	GF SF	0.15-5.0	0-5	10-30	0-15	6	(5)	Low to intermediate resistance. Heavier compaction and higher plasticity index increase the resistance.	(4)	Intermediate susceptibility.	(4)	Most likely to fail by piping. May possibly fail by cracking.

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Ref. "Flexibility of Clay and Cracking of Earth Dams"

by G. A. Leonards and J. Narain

Proceedings, Part 1, ASCE, Vol. 89, No. SM2, March 1963, pp. 47-97

III	Inorganic silts of low compressibility and fine silty sands	ML ML-CL ML-SC ML-SF	0.03-0.15	0-10	10-45	0-25	12	(6)	Uniform sand with P.I. < 6 has lowest resistance. Well-graded material with P.I. > 6 has intermediate resistance.	(2)	High susceptibility. The finer and more uniform the soil, the greater the susceptibility.	(1)	High probability of failure by piping and cracking.
IV	Inorganic silts and clays of low medium plasticity	CL ML	0.10	10-25	20-50	10-40	30	(4)	P.I. < 15 - intermediate resistance.	(1)	Material with D ₅₀ > 0.02 mm and P.I. < 15 has highest susceptibility.	(2)	Most likely to fail by cracking. May fail by piping.
								(2)	P.I. > 15 - high resistance.	(5)	Material with D ₅₀ < 0.02 mm and P.I. > 20 has high post-construction settlement but sufficient deformability to follow without cracking.	(1)	May fail by cracking or piping only under severe combinations of detrimental conditions.
V	Inorganic clays of high plasticity	CH CL-CH	0.02	25-40	40	30	6	(1)	High piping. Resistance not severely lowered by very poor compaction.	(6)	Unlikely to crack. High post-construction settlement but high deformability.	(6)	Least likely to fail by either piping or cracking.

^a In general, the coarser the soil and the less the plasticity, the greater the increase in piping resistance due to increased compactive effort.

^b Susceptibility to cracking was not observed to be decreased appreciably by increase in compactive effort. Rapidly disintegrating residual soils may be especially susceptible to cracking.

^c No dams constructed of soils with plasticity index greater than 40 were included in the investigation. (After Sherard)

STATE VIRGINIA

PROJECT

BY CAW DATE 8 June 65

CHECKED BY

DATE

QUALITY
JOB NO

SUBJECT

PIPING & CRACKING

VA 499
SHEET 5 OF 7

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(1) greatest (6) least

SAMPLE	DEPTH	U.S.C.S.	D ₅₀ mm	P.I.	LL	% 005 mm	PIPING *	CRACKING *	Required REMARKS Moisture Content
15F 157	1-11'	SM	.15	2	20	11	5	4	3
158	1-9'	CL	.07	9	29	19	6	2	1
* 162	1-8'	SM	.15	1	17	7	5	4	3
167	1-45'	SC-SM	.07	4	21	22	6	2	1
168	45-92'	SM	.15	0	16	15	5	4	3
65F 156	39-98'	SM	.42	3	21	9	5	4	3
159	1-7.7'	GM	38	NON-PLASTIC	"	6	5	4	3
160	1-7.5'	GM-GP	19	"	"	4	5	4	3
161	6'-8.6'	SM	.4	"	"	6	5	4	3
* 166	1-9'	GM	2.0	4	22	11	5	4	3
169	1-6'	SM	0.6	1	19	13	6	2	1

* DEGREE OF SUSCEPTABILITY (1 GREATEST TO 6 LEAST) TAKEN FROM "FLEXIBILITY OF CLAY AND CRACKING OF EARTH DAMS" BY LEONARDS & NARAIN, ASCE PROCEEDINGS VOL. 89, SM 2, MARCH 1963, PP 50 & 51

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CONSULTING ENGINEERS **RICHMOND, VIRGINIA**

BY C.A.W. DATE 6/65 SUBJECT DAM #83 - HONES QUARRY SHEET NO. 1 OF 1
CHKD. BY _____ DATE _____ JOB NO. VA-499
_____ PIPING _____

Piping across Interfaces - Shell to Core, Core to Foundation Aluvium.

The criteria of Piping Safety will be that the D15 size of the coarser material shall \leq 5 times the D85 size of the finer material.

1. SHELL TO CORE

All sizes in mm.

CORE			SHELL		COMMENTS
SAMPLE	D85	5 x D85	SAMPLE	D15	
65F157	4.5	22.5	65F156	.02	
65F158	4.5	22.5	65F159	.09	
65F162	2.6	13	65F160	0.20	
65F167	0.4	2.0	65F161	.055	
65F168	4.7	23.5	65F166	.03	
			65F169	.01	

Criteria D15 Shell \leq 5 x D85 Core.

The criteria is not violated by any combination of shell against core borrow.

2. SHELL & CORE to FOUNDATION ALUVIUM -

A study of test pit and drill hole data reveals that the entire foundation aluvium is essentially GM material with exception of its surface, which will be removed. Test pits 401 and 501 seem representative of this material when compared with test pits 3, 302, 306 and are reasonably uniformly graded, with approximately 50% finer than 3" size. These foundation materials should present no piping problems with the shell such as sample 65F166 (borrow). Some caution must be exercised in field placement of core in contact with the foundation to assume matching of material gradation as closely as possible. In other words, the coarser of the acceptable core borrow should be placed against the foundation aluvium in the core-foundation interfaces.

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